IDC DOCUMENTATION

Analyst Instructions for Radionuclide Data

Revision 2

Notice

This document was published by the NBC Defense Systems Group of Veridian as part of the International Data Centre (IDC) Documentation. It was first published in March 1999, updated and republished electonically as Revision 1 in November 2000, and was republished electronically as Revision 2 in December 2001 to include major changes. IDC documents that have been changed substantially are indicated by a whole revision number (for example, Revision 2).

Contributors

Michael J. Pickering, Veridian
Erik Swanberg, Veridian
Hallie Magyar, Veridian

Trademarks

Ordering Information

The ordering number for this document is TN2873.

This document is cited within other IDC documents as [IDC6.2.6Rev2].

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

About this Document

This chapter describes the organization and content of the document and includes the following sections:

About this Document

PURPOSE

This document, *Analyst Instructions for Radionuclide Data, Revision 2* [IDC6.2.6Rev2], describes the interactive analysis of radionuclide data, including the review processes for high-resolution gamma-ray spectra and three dimensional (3-D) beta-gamma coincidence data. The interactive review process is a necessary step in the creation of a Reviewed Radionuclide Report (RRR).

This document supersedes the information contained in *Analyst Instructions for Radionuclide Data, Revision 1*, published November 2000, and provides revised interactive review instructions that incorporate the latest features of the radionuclide software.

SCOPE

This document includes general instructions for the interactive review of radionuclide data and automatic analysis results. The methodology for these procedures is based on International Data Centre (IDC) requirements.

AUDIENCE

This document is intended for IDC radionuclide analysts and other members of radionuclide operations who will participate in interactive review of radionuclide data. It is assumed that these individuals have a basic understanding of atmospheric radionuclide monitoring, gamma-ray spectroscopy, and beta-gamma coincidence data.

RELATED INFORMATION

See “References” on page 58 for a listing of all the sources of information consulted in preparing this document.

USING THIS DOCUMENT

This document is part of the overall documentation architecture for the IDC and is part of the Products and Services document category, which provides descriptions of IDC products and their formats. This document is organized as follows:

- Interactive Review Procedures for Gamma-ray Spectra

  This chapter provides step-by-step instructions for the interactive analysis of radionuclide full sample spectra.

- Interactive Review of 3-D Beta-gamma Coincidence Data

  This chapter provides step-by-step instructions for the interactive analysis of 3-D beta-gamma coincidence data.

Conventions

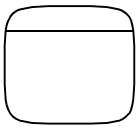
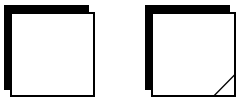
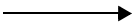
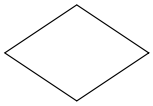
This document uses a variety of conventions, which are described in the following tables. Table I shows the typographical conventions.

TABLE I: TYPOGRAPHICAL CONVENTIONS

Element	Font	Example
database table	**bold**	**dataready**
database table and attribute when written in the dot notation		**prodtrack.***status*
attributes of database tables when written separately	*italics*	*status*
processes and software units		*ParseSubs*
user-defined arguments		`delete-remarks`*object*
computer code and output	`courier`	`>(list ‘a ‘b ‘c)`
filenames, directories, and websites		`amp.par`
text that should be typed in exactly as shown		`edit-filter-dialog`

Table II shows the conventions for data flow diagrams.

TABLE II: DATA FLOW SYMBOLS

Description	Symbol
process	
external source or sink of data (left) duplicated external source or sink of data (right)	
data store (left) duplicated data store (right)	
control flow	
data flow	
decision	
product	

▼ About this Document

Chapter 1: Interactive Review Procedures for Gamma-ray Spectra

This chapter describes the standard procedures for IDC radionuclide spectral analysis and includes the following sections:

Chapter 1: Interactive Review Procedures for High-Resolution Gamma-Ray Spectra

INTRODUCTION

A simplified flow diagram of the radionuclide review described in this document is shown in Figure 1. The flow diagram starts with data arrival and automatic analysis. These topics are covered in *IDC Processing of Radionuclide Data* [IDC5.2.2Rev2] and the "Radionuclide Import Processing" chapter in *Radionuclide Software Design* [IDC7.1.10Rev2]. After receipt, spectra are prioritized with respect to their urgency for review. Spectra with Comprehensive Nuclear Test-Ban Treaty (CTBT)-relevant anthropogenic radionuclides are given higher priority than spectra with only natural radionculides [CTB00b]. Spectra are also prioritized with respect to how long they have been in the analysis queue. During spectral review, the sampling metrics, spectral calibrations, and data reports are examined. The spectrum is also searched for Type I (peaks found in automated processing that are not truly there) and Type II (peaks missed by automatic processing) peak search errors. If no analysis problems or abnormalities are found and no CTBT-relevant anthropogenic radionuclides are identified, the spectrum is released with a categorization level and post-review products are generated. The spectrum is passed along to other staff for review if: 1) an analyst finds problems with the automatic spectrum analysis results; 2) adds or modifies a peak associated with a CTBT-relevant anthropogenic radionuclide; or 3) abnormal concentrations of radionuclides contained in the categorization list for particulate samples (CLPS) are identified [CTB00b].

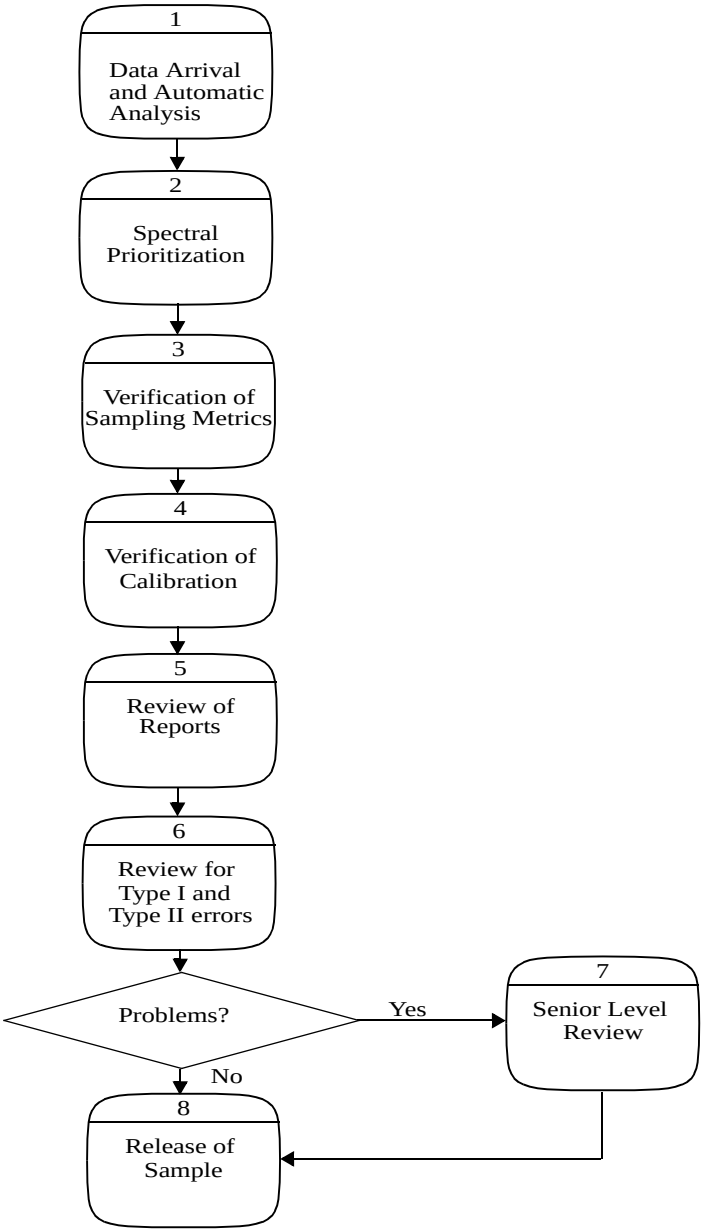


FIGURE 1. RADIONUCLIDE REVIEW FLOW DIAGRAM

Once received, sample data from the International Monitoring System (IMS) are automatically analyzed and prioritized, and the results are stored in an ORACLE database. The job of the radionuclide analyst is to review the results of the automatic processing and to monitor the state of health (SOH) of the radionuclide station equipment. Samples that require peak insertions or peak modifications, contain abnormal levels of relevant radionuclides, or have special problems, will be forwarded to other IDC staff for additional review.

The IDC receives several types of pulse height data (PHD). This chapter contains guideance for reviewing the two-dimensional (2-D) data produced by stations reporting gamma-ray spectroscopy. PHD files are produced for a variety of sample types: blank, calibration, detector background, quality control, and sample. The formats of all PHD types are explained in [IDC3.4.1Rev3].

- Blank pulse height data (BLANKPHD) files are produced by the gamma-ray acquisition of a blank aerosol filter. This gamma-ray spectrum provides information regarding the background levels around the detector as well as information regarding the radionuclides present in the blank filter. Most filters have notable activity concentrations of ^{40}K.
- Calibration pulse height data (CALIBPHD) files are produced for determining the calibration (energy vs. channel, resolution vs. energy, and efficiency vs. energy) of the detector instrumentation. The CALIBPHD is produced by the gamma-ray acquisition of a certified radionuclear source positioned on the detector in a known geometry. The IMS has defined the requirements of calibration sources in “[CTB99a]” on page 58.
- Detector background pulse height data (DETBKPHD) files are produced for determining the background levels on and around the detector instrumentation. Nothing is present in the detector chamber when the gamma-ray spectrum is acquired. The counts in the DETBKPHD may also be subtracted from the counts in the BLANKPHD (adjusted for acquisition time differences) to provide an understanding of the activity contained in the blank filter.

- Quality control pulse height data (QCPHD) are similar to CALIBPHD in that they are both gamma-ray acquisitions of a known certified radioactive source. However, the QCPHD is counted on a daily basis and usually for a shorter period of time. The QCPHD is used to monitor detector SOH.
- Sample pulse height data (SAMPLEPHD) files are produced from the gamma-ray acquisitions of particulate and noble gas samples. SAMPLEPHD files can be either a preliminary (PREL) file or a full (FULL) file. The PREL file is counted for a portion of the total acquisition time associated with the FULL file, and arrives at the IDC first. The PREL files provides the analyst with a method of calulating the halflife of any identified relevant radionuclides, based on a comparison of the peak areas identified in each of the PREL and FULL files. This has applications in time-critical radionuclide detections. SAMPLEPHD files may contain beta-gated gamma spectra if the originating station has an ARIX noble gas collection unit. For every sample collected by an ARIX unit, two SAMPLEPHDs are transmited: one containing a low-resolution gamma-ray spectrum and one containing a beta-gated gamma spectrum. The gamma spectrum is used to identify and quantify ^{131m}Xe and ^{133m}Xe. the beta-gated gamma spectrum is used to identify and quantify ^{133}Xe and ^{135}Xe.

Radionuclide analysts interactively review all FULL SAMPLEPHD files coming from IMS stations. The PREL SAMPLEPHD, DETBKPHD, BLANKPHD, QCPHD, and CALIBPHD spectral files are not routinely reviewed by the analyst; however, these spectral files do provide additional information.

SPECTRAL PRIORITIZATION OF SAMPLES

After automatic analysis, FULL SAMPLEPHD spectra are prioritized. The radionuclide analysis software assigns the spectrum one of five levels. The logic of the prioritization levels is shown in Figure 2 and Figure 3. Level 1 spectra contain only natural radionuclides and non-relevant radionculides at normal levels. Level 2 spectra contain natural and non-relevant radionuclides at abnormal levels for that station.[1] Level 3 spectra contain one or more relevant radionuclides at normal levels for that station. Level 4 spectra contain at least one relevant radionuclide at an abnormal level for that station. Level 5

spectra contain more than one CLPS radionuclide at an abnormal level for that station, with one of these radionuclides being a fission product. Both Level 4 and Level 5 spectra require that additional atmospheric location analyses are performed. The Level 5 spectra also require additional analytical methods to be performed by IMS radionuclide laboratories. The prioritization processing is explained in detail in [IDC7.1.10Rev2]. The list of CLPS radionuclides can be found in [CTB00b].

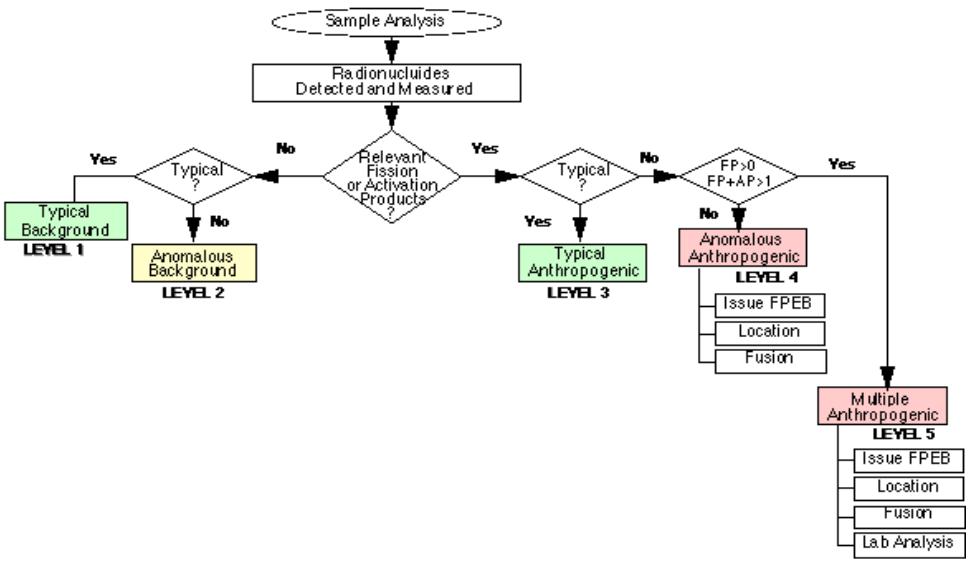


FIGURE 2. PARTICULATE SAMPLE PRIORITIZATION/ CHARACTERIZATION

Although there are now two different characterization algorithms used in the Detection Processing software (exponentially weighted moving average and recent distribution calculation) [IDC7.1.10Rev2], it is still advisable that all spectra from a given IMS station be reviewed in chronological order based on the filter collection times. This method of review will always ensure that the characterization statistical filter values are correctly maintained.

1. It is not possible to have two noble gas samples due to the inherent nature of the separation process used to obtain samples.

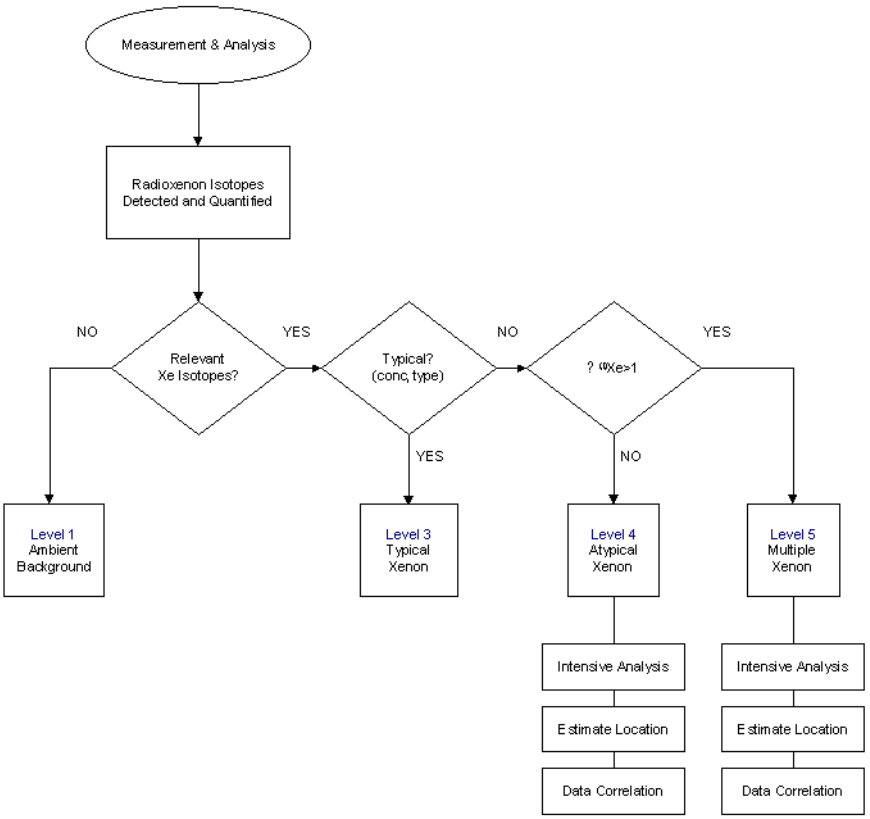


FIGURE 3. NOBLE GAS SAMPLE PRIORITIZATION/CHARACTERIZATION

Each radionuclide analyst is generally responsibile for reviewing samples from a number of IMS stations. Review responsibilities are generally assigned by the radionuclide Lead Analyst or the unit head of Radionuclide Operations. Each day, the analysts may look in the Sample Assignment Queue to see the processed FULL SAMPLEPHD files that require interactive review. Spectra are generally prioritized with respect to their automatic prioritization levels. Level 5 (multiple relevant radionuclides at abnormal levels) spectra are reviewed first. Level 1 (typical background) spectra are last in priority. Within each automatic prioritization level, spectra are further prioritized based on how

long they have been in queue. The longer a given spectrum has been in the queue, the higher the priority it receives. All spectra should generally be reviewed within 1 day of receipt.

MULTIPLE ANALYST REVIEW TOOL

The Multiple Analyst Review (MAR) Tool is designed to aid in the spectral review process. This tool administers the assignment of samples for review. Analysts may open the Sample Assignment Queue from the Spectrum pull-down menu in Inspectra (Spectrum>Sample Assigment Queue). An example of the Sample Assignment Queue is shown in Figure 4. The analyst selects the appropriate role identity from the drop-down menu in the lower right corner. All the samples to be reviewed are then displayed, and may be selected and opened in Inspectra.

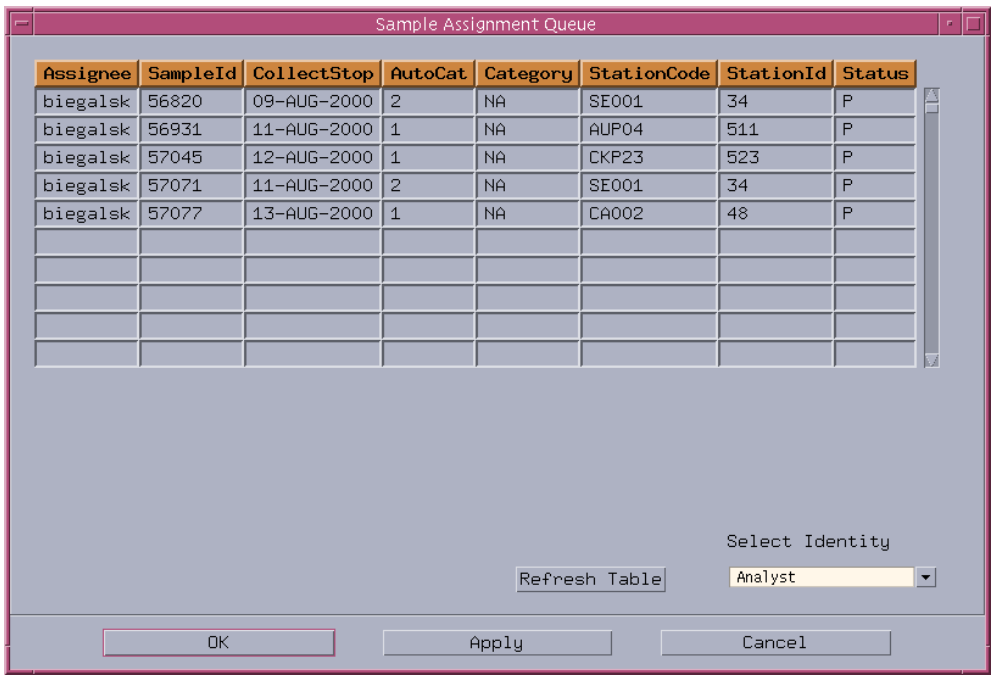


FIGURE 4. MAR TOOL SAMPLE ASSIGNMENT QUEUE

VERIFICATION OF SAMPLING METRICS

To begin spectral review, a radionuclide analyst selects the spectrum with the highest prioritization from their queue. This spectrum is then opened with the Inspectra tool. A detailed description of the Inspectra tool may be found in [IDC6.5.10Rev2]. Once opened, the first step in spectral review is to check the sampling metrics.

The first step in determining if everything was collected in a normal manner is to look at the station and general comments. If anything abnormal occurred during the sampling or gamma-ray acquisition, the station operator will often place a station comment within the SAMPLEPHD file. This comment can be viewed by choosing the View Station Comments option from the Spectrum menu. (Spectrum>View Station Comments). At this time, the radionuclide analyst should also view the general comments (Spectrum>View General Comments). The pipeline engineers at the IDC may insert general comments about problems with the automatic sample process, or steps taken to manually re-analyze the sample. At present, all ARIX SAMPLEPHD will likely have to be manually reanalyzed due to the unique nature of the data.

The next step in reviewing the sampling metrics is to look at the flow-rate, sampling time, decay time, and acquisition time. These values are labeled FR, ST, DT, and AT in the Inspectra window (see Figure 5), respectively. An analyst who is familiar with a station's sampling methodology should be able to recognize if these values are normal for the station. If a station's sampling methodology is not familiar, the analyst may check the sample detail dialog (Reports>Sample Detail) . Figure 6 shows the sample detail dialog, which provides the average quantity, sampling time, decay time, and acquisition time for the station of interest. The average values are calculated from the spectral data collected over the previous month at that station.

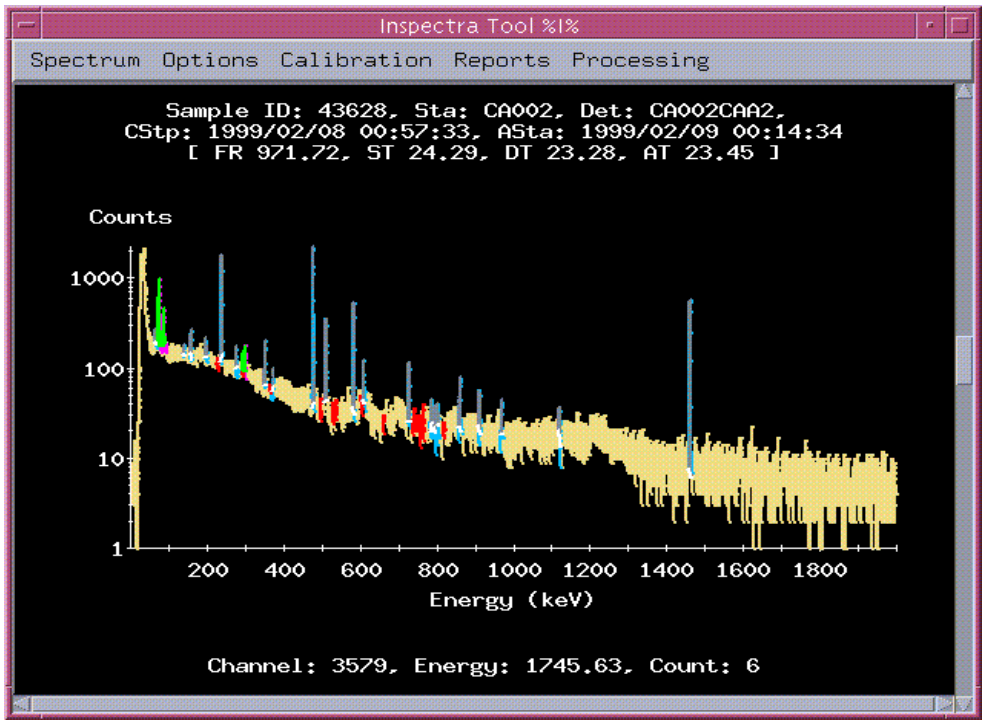


FIGURE 5. INSPECTRA WINDOW

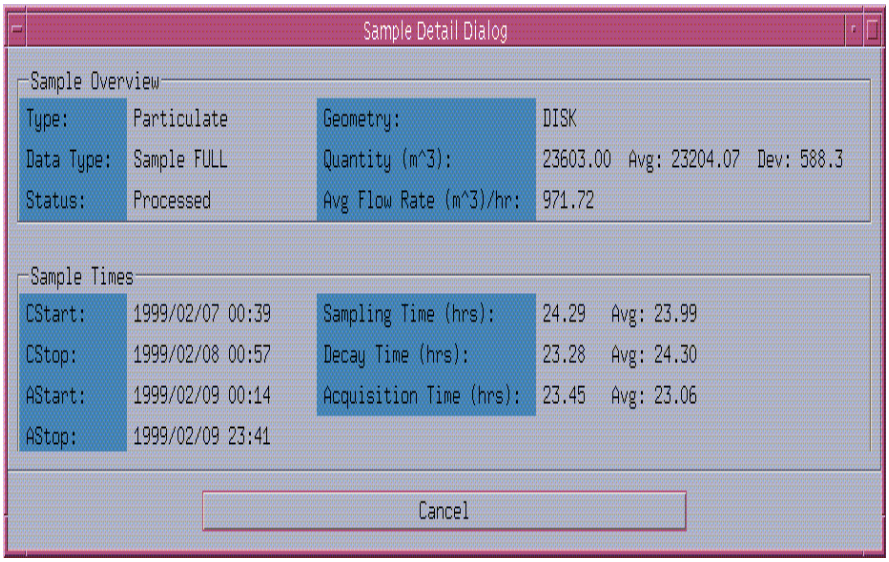


FIGURE 6. SAMPLE DETAIL DIALOG

The report on the database quality flags (Reports>Database Quality Flags) provides additional information with regard to the sampling and timeliness metrics (see Figure 7). The database flags were created to provide basic information with regard to the quality and timeliness of particulate spectra. The database flags report provides information on the flow-rate, ^{140}Ba minimum detectable concentration (MDC), ^{7}Be full width at half-maximum (FWHM), ^{40}K location difference, normalized gain difference, relevant timeliness information, and the time difference between the receipt of the raw spectrum data and the creation of the data flag report.

Any abnormalities in the sampling metrics deserve further investigation. This often requires contacting the station to ascertain if the abnormal value is an inadvertent error or is representative of the true value. All abnormalities in the sampling metrics, as well as corrections made to these values, should be noted in the general comments (Processing>Add General Comment) and the station should be contacted through internal procedures set up by the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO).

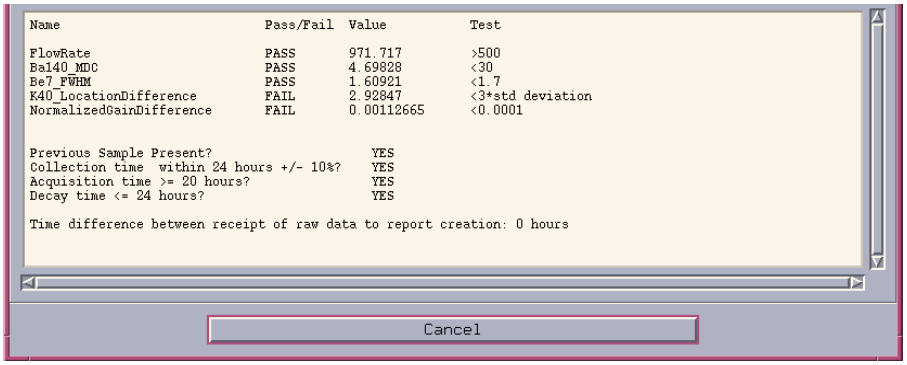


FIGURE 7. DATABASE QUALITY FLAGS (PARTICULATE SAMPLES ONLY)

VERIFICATION OF CALIBRATION

Three calibration equations are used in the analysis of high-resolution gamma-ray spectra: 1) energy versus channel regression (ECR), 2) resolution versus energy regression (RER), and 3) efficiency versus energy regression (EER). The ECR and RER are spectrum specific and are calculated during the analysis process. The calibration equations of the most recent prior (MRP) spectrum from the same detector are most often used as a starting point. The major peaks in the spectrum are found and identified. These peaks are used to update the energy versus channel and resolution versus energy regression equations. The results are termed the ECRU and RERU, respectively. The EER is not updated for every spectrum. The EER is derived from the most recent calibration at the station; the pair data for the efficiency calibration is provided in the PHD file. Details about the calibration equation calculations are given in [IDC5.2.2Rev2]. For information on calibration equations for analysis of ARIX samples, see [Pop01].

The first step in verifying the calibration of the sample is to examine the spectrum in a view that displays the entire energy range. The radionuclide analyst should be able to pick out the primary lines of the spectrum and verify that they are present and in the correct energy vicinity. Large peaks utilized for this step normally include the 238 keV peak of ^{212}Pb, the 477 keV peak of ^{7}Be, the 583 keV peak of ^{208}Tl, and the 1460 keV peak of ^{40}K. With normal sampling methodology, all of these peaks should be visible in the spectrum, as shown in Figure 5. If these peaks are not present, then the analyst should

investigate their absence. Sometimes the peaks may be present, but at the wrong energy. This is indicative of a gain shift in the detector's amplifier and the spectrum should be manually re-analyzed. Instructions for manual sample analysis can be found in the "Processing Tools" chapter of [IDC6.5.10Rev2] and in [Pop01] for ARIX samples. Generally, the calibration update is capable of handling most gain shifts. Large gain shifts may result in a failed automatic analysis.

The radionuclide analyst should also briefly examine the spectrum to ensure the detector resolution is appropriate. To do this for particulate samples, expand the display on the 477 keV ^{7}Be line. The FWHM of the peak should appear to be less than 2 keV. This is not a precise way to determine the FWHM, but it provides a general impression. (The analyst should mark this FWHM estimate for comparison with the automatic analysis results.) If the resolution of the spectrum is too high, it is likely the result of detector electronics problems and the IMS should be notified. The analyst should also be alert for "shadow peaks" next to the large peaks in the spectrum. These peaks are the result of amplifier oscillations or shifts during the gamma-ray spectrum acquisition. These problems may result in an unusable spectrum for quantitative radionuclide analysis. Spectra that cannot be used for quantitative results are usually marked "Viewed" and are not released; however, other actions may be taken if CTBT-relevant radionuclides are present in the spectrum. These checks of the detector energy and resolution calibrations should only take seconds for an experienced radionuclide analyst.

Next, calibrations are investigated by observing the reports available in the Calibration menu. The first report is the calibration equations dialog (Calibration>Equations) (Figure 8). It may take time for an analyst to become familiar with the correct fit variables in these equations. In general, the ECR for a 4096 channel spectrum with a range of 2 MeV should have a slope just under 0.5 (the slope is the second coefficient in the equation). The RER is a square-root function. Only two variables are fit in this equation and they may change on a detector-by-detector basis. The third calibration function is the EER. This equation is complex and the analyst is not expected to be familiar with the range of variables fit to this equation.

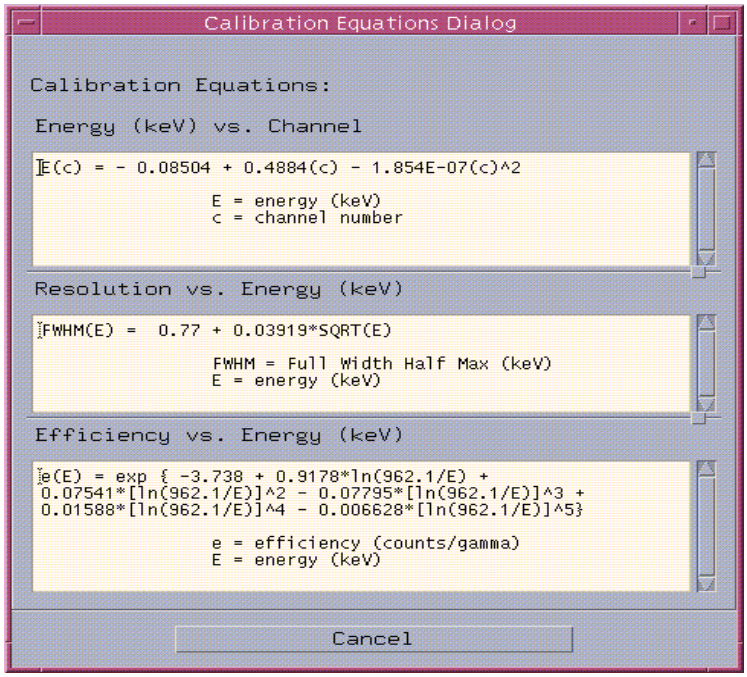


FIGURE 8. CALIBRATION EQUATIONS

The calibration pairs dialog (Calibration>Pairs) is the next report an analyst should view in verifying the detector calibration (Figure 9). These are the data used to fit the calibration equations listed above. It is important to realize that the energy and resolution pairs are a result of the automated analysis process for that individual spectrum. In a particulate sample spectrum, the energy and resolution pairs are from natural radionuclide peaks in the gamma-ray spectrum. A reference list of peaks expected to be found in each spectrum, based on sample and detector type, is stored in the database. The analyst should note what natural peaks were found. If some of the major natural peaks in the spectrum were not used for the energy and resolution calibration, the analyst should investigate further. The efficiency pair data originate from the last CALIBPHD acquired for that detector. All values should be reviewed to make sure they fall into a realistic range.

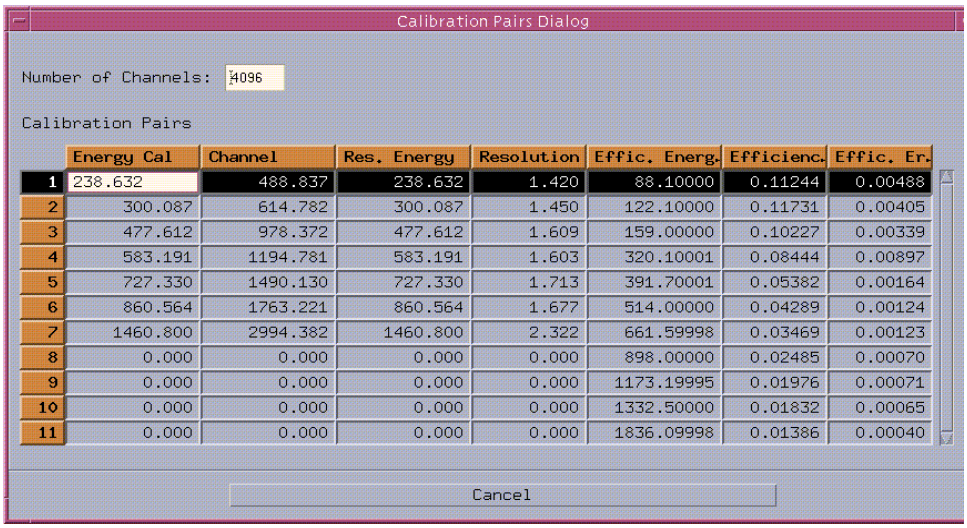


FIGURE 9. CALIBRATION PAIRS DIALOG

The plots of the energy, resolution, and efficiency calibrations should be reviewed next (Calibration>Energy Function Plot, Calibration>Resolution Function Plot, and Calibration>Efficiency Function Plot). Examples of these plots are given in Figures 10, 11, and 12, respectively. The energy function plot is actually a discrepancy plot, while the resolution and efficiency function plots are the graphs of the actual RER and EER, respectively. The energy discrepancy is the difference between the actual energy calibration and a perfectly linear calibration. The analyst should look for large outliers in these plots and verify that the fitted equations properly fit the data over the entire calibration range.

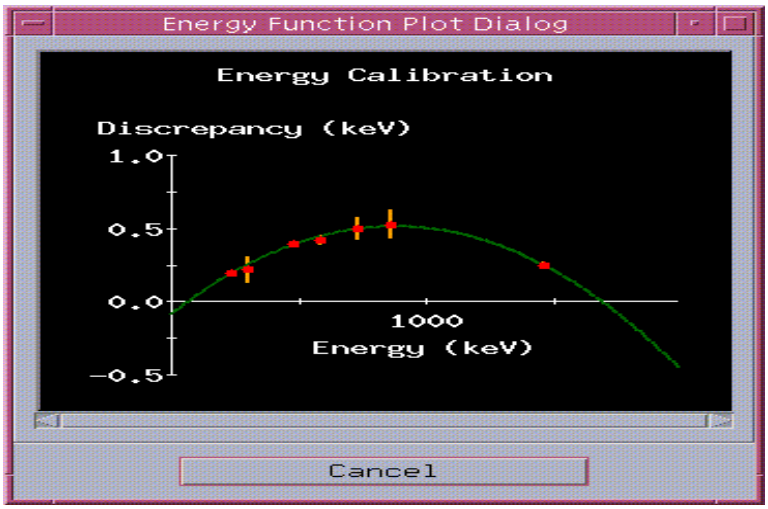


FIGURE 10. ENERGY FUNCTION PLOT DIALOG

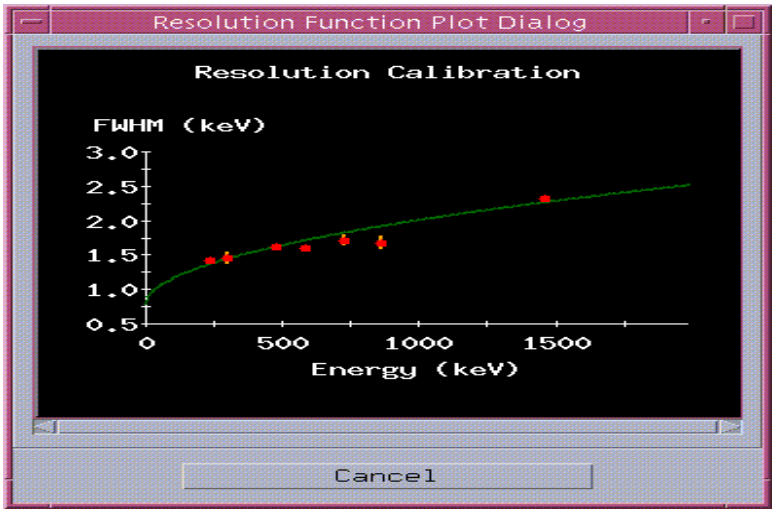


FIGURE 11. RESOLUTION FUNCTION PLOT DIALOG

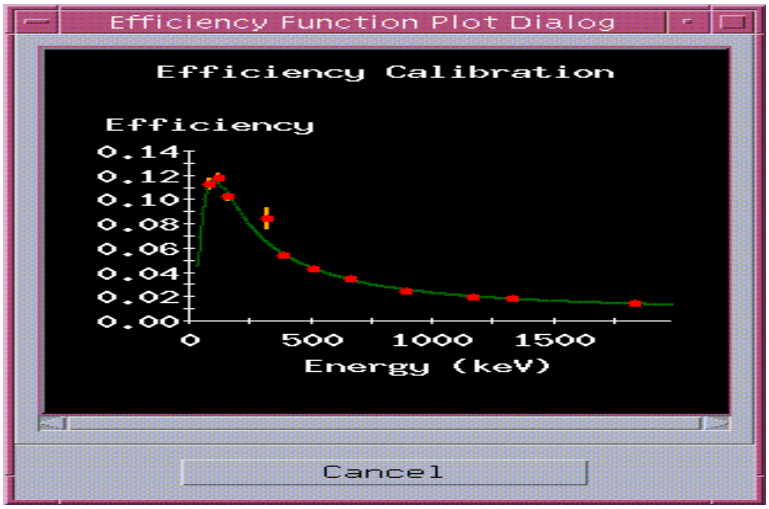


FIGURE 12. EFFICIENCY FUNCTION PLOT DIALOG

REVIEW OF REPORTS

The radionuclide analyst should examine the reports once the sampling metrics and spectral calibration are reviewed. The analyst should already know the prioritization level from the Sample Assignment Queue. Nuclide prioritization levels, activities, and statistical prioritization limits may be found in the Categorization report (Reports>Categorization). A detailed description of nuclide prioritization may be found in [IDC6.5.10Rev2]. During review, the analyst should pay special attention to CTBT relevant nuclides [CTB00b].

Next, the analyst should select the peak search summary report (Reports>Peak Search Summary). This report provides the analyst with the number of lines (peaks) found in the spectrum, the number of lines associated with nuclides, the number of lines not associated with nuclides, and the percent of lines associated with nuclides. The number of peaks found in a gamma-ray spectrum greatly depends on the station location, detector, sampling methodology, and processing parameters. In general, an analyst may expect to find 30 to 50 peaks in a particulate spectrum. Out of those peaks, more than 90% should

be associated with a nuclide. Due to sample separation processing at the station, very few peaks will generally be found in noble gas spectra. An analyst should investigate cases outside of these nominal bounds.

The radionuclide activity summary report should also be helpful to the radionuclide analyst (Reports>Radionuclide Activity). All quantified radionuclide activity concentrations are listed in this window. Some natural radionuclide activity concentrations are not quantified due to the complexity of concentration calculations for radionuclides in a decay chain; see [IDC5.2.2Rev2] for more information on how nuclides are quanitifed.

The MDC (Reports>Minimum Detectable Concentrations) report should be examined to ensure that the MDCs are at acceptable levels. The MDC is a function of many parameters including sampling methodology, station background activity levels, as well as detector background activity levels. The analyst should be familiar with the range of MDCs observed at a given station. If the analyst is not familiar with the range of normal MDCs for a given detector, then they may be plotted with the Trendvue application [IDC6.5.10Rev2]. The radionuclide analyst should be mostly concerned with verifying that the MDCs are within a normal range, as well as checking them against the IMS criteria. The MDC is a good metric of the station SOH and the analyst should report notable degradations in MDCs to the IMS. Some of the radionuclides (for example, ^{99}Mo) may not always be below the maximum allowable MDC. The analyst should be familiar with such cases and should know what MDCs are acceptable for a given station. The MDCs usually trend together. Quite often, monitoring the state of one MDC (such as ^{140}Ba) will show the behavior of the other MDCs.

The peak search report (Reports>Peak Search) is the last report an analyst should review. This report is large and should be reviewed in detail (Figure 13). Consequently, it will take more time than the other reports. The Peak Search report contains information for each peak regarding the centroid energy, centroid channel, multiplet flag, background subtraction flag, channel width of the corresponding Region of Interest (ROI), FWHM, width ratio (fitted peak width divided by expected peak width), area, area uncertainty, peak significance, calculated Lc value, nuclide identification, and analyst comments. An analyst may sort this report by any of the corresponding fields by selecting the column

header. During review, this report is normally sorted with respect to either peak energy or nuclide. The results for all anthropogenic nuclides as well as the natural nuclides used for characterization should be reviewed.

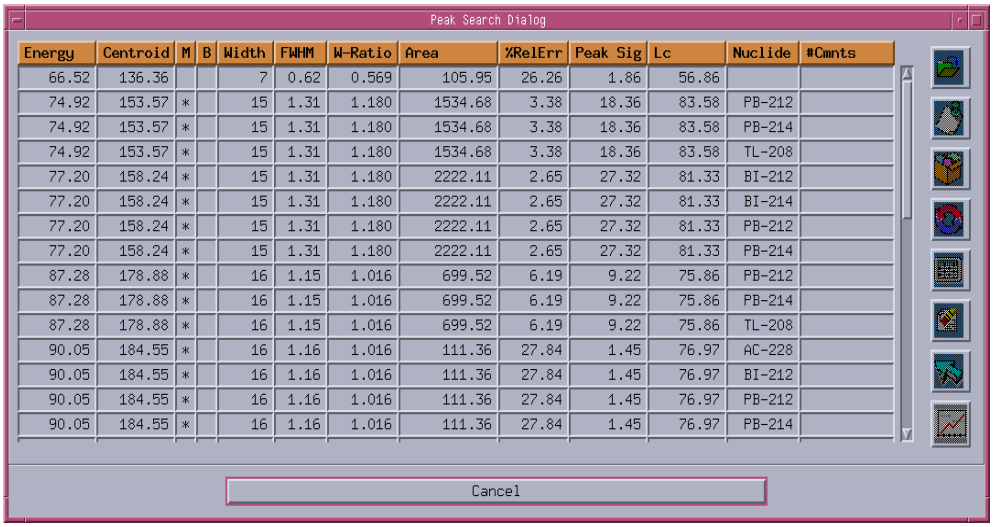


FIGURE 13. PEAK SEARCH DIALOG

As shown in Figure 13, peaks are sometimes associated with multiple radionuclides. This particular peak search report shows peaks found in the low-energy region of a particulate sample. In almost every particulate spectrum, the Canberra nuclide identification process associates multiple radionuclides for the peaks in this region. It is the analyst's job to determine the correct nuclide identification for these peaks. If an analyst believes a nuclide identification to be incorrect, then the nuclide should be removed from the activity summary (use the "Remove Nuclide" button in the Peak Search Dialog) and the line(s) in the peak search dialog should be properly commented. The toolbar buttons on the side of the peak search dialog window allow the analyst to view comments, add comments, note detector contamination, modify comments, view line activities, remove nuclides, add back removed nuclides, and show peak graphs in the main Inspectra window. Inspectra only allows analysts to modify their own comments on spectra that have not been released.

Table 1 lists comments added to a specific peak in the peak search report for a particulate sample from the Vancouver, Canada station. For this sample, ^{99m}Tc was removed from the activity summary report, but only after the sample was passed on for senior-level review. The operational policy for removal of nuclides is set by the Director of Radionuclide Operations and is likely to be station-specific.

TABLE 1: PEAK SEARCH REPORT COMMENTS

Energy (keV)	Nuclide	Comment
140.06	^{75m}Ge	The peak near 140 keV has two possible explanations: ^{75m}Ge (product of the detector material activation by cosmic radiation) or ^{99m}Tc (fission product). Both nuclides are monoemitters and their primary line energies are so close in energy so that with the current peak centroid energy uncertainty it is difficult to differentiate one from the other by centroid energy alone.
140.06	^{99m}Tc	This nuclide was removed from the Activity Summary section because in the analyst's judgment the nuclide was not present; some nuclides may be removed because their activity calculations are not meaningful (they are identified, not quantified). ^{99}Mo, "parent" nuclide for ^{99m}Tc, is absent in this spectrum which leads to the conclusion that this spectrum is not the direct result of a fission event release. However, the detection limits for the two nuclides are such that ^{99}Mo could be present at levels just below the level of detection and ^{99m}Tc could be present at levels just above the level of detection. The peak near 140 keV has two possible explanations: ^{75m}Ge (product of the detector material activation by cosmic radiation) or ^{99m}Tc (fission product). Both nuclides are monoemitters and their primary line energies are so close in energy so that with the current peak centroid energy uncertainty it is difficult to differentiate one from the other by centroid energy alone.

In order to aid the analyst in determining the validity of the peak search results, a scatter plot displaying the Canberra Peak Significance vs. Peak Search Sensitivity (PSS) for each peak found during analysis is now available (see Figure 14). In addition to the scatter plot, a table with peak search results is provided. Most of the columns displayed in the table are identical to those found in the Peak Search window, with the exception of the PSS column. The analyst can zoom into the plot by depressing the SHIFT key and

the left mouse button simultaneously. The analyst has the option to display each of the plot axes in either linear or log format by simply clicking the buttons provided. When a user selects a point on the scatter plot, the corresponding row in the table is highlighted. A Show Graph toolbar button like the one in the Peak Search Dialog window is provided, so the user can zoom into the graph area on the main Inspectra window.

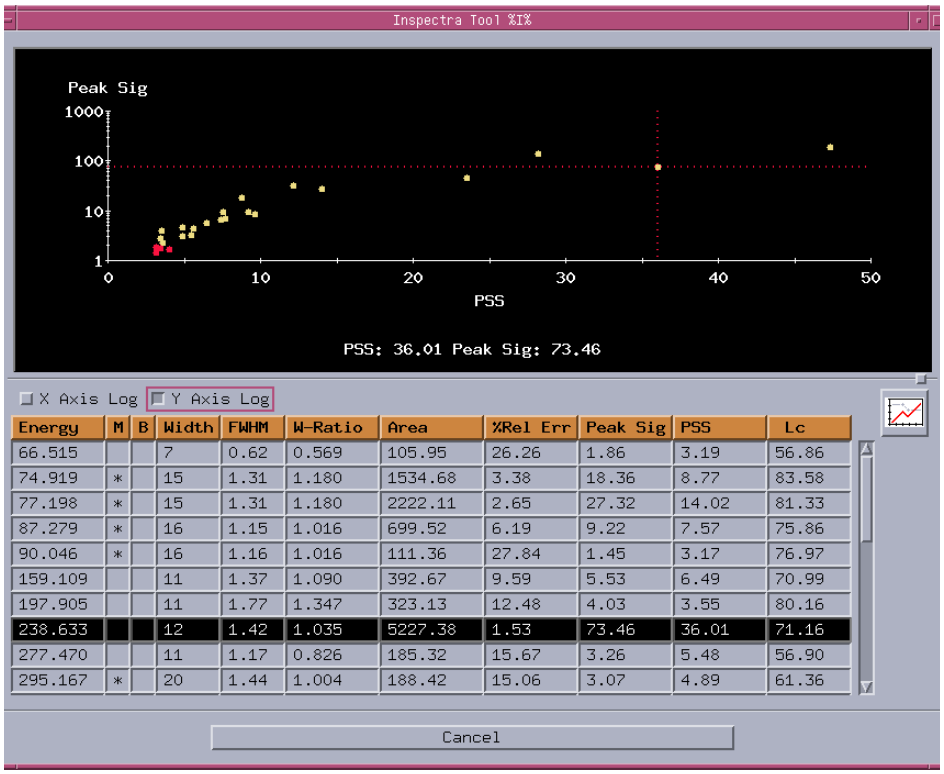


FIGURE 14. PEAK SIGNIFICANCE/PSS DIALOG

All CTBT-relevant anthropogenic radionuclides should be examined with the compare feature (see Figure 15). The FULL spectrum can be compared with any of the PREL spectra associated with the current filter sample, in order to confirm the presence of a specific peak. Radionuclides with short half-lives should stand out in the preliminary spectra. Comparisons between the PREL and FULL spectra may also be utilized to calculate radionuclide half-lives. This is especially useful for differentiation between ^{99m}Tc

and ^{75m}Ge, given the fact that both nuclides are mono-emitters, with a single emission line at nearly the same energy location. Comparison of PREL and FULL spectra may also be useful to confimr the pressence of ^{131m}Xe, ^{133m}Xe, and ^{135}XE in noble gas samples. If a radionuclide found in the FULL spectrum is used in calibration sources, then the most recent blank or detector background spectra should be examined for contamination.

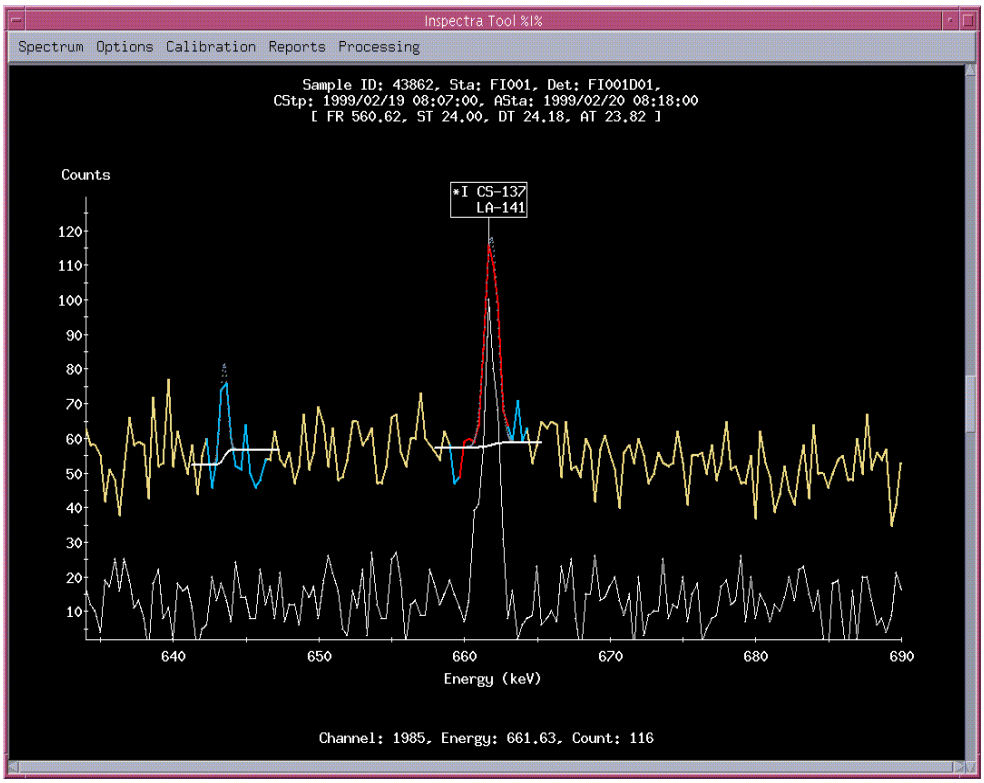


FIGURE 15. COMPARE FUNCTION

Table 2 lists nuclides often used in calibration sources.

TABLE 2: RADIONUCLIDES COMMONLY USED IN CALIBRATION SOURCES

Nuclide	Half-life
^{51}Cr	27.7 days
^{54}Mn	312 days
^{57}Co	272 days
^{60}Co	5.27 years
^{85}Sr	64.8 days
^{88}Y	107 days
^{109}Cd	462 days
^{113}Sn	115 days
^{123m}Te	120 days
^{131m}Xe	11.9 days
^{133}Xe	2.19 days
^{133}Ba	388 days
^{137}Cs	30.2 years
^{139}Ce	137.6 days
^{152}Eu	13.5 years
^{154}Eu	8.59 years
^{203}Mg	46.6 days
^{241}Am	432.2 years

While reviewing the peaks in a spectrum, the analyst should verify that they are fit properly. This is especially true for anthropogenic radionuclides. To aid in determining the quality of a peak fit, the analyst may use the residuals plot (see Figure 16). Good peak fits will have small residuals. Corrective action can be taken to modify the peak fit with the Region of Interest (ROI) interface (Options>ROI) (see Figure 17). To modify a peak, proceed as follows.

1. Click the Left button, then click on the spectrum where the left bounds of the peak ROI should be located.
2. Click the Right button, then click on the spectrum where the right bounds of the peak ROI should be located.
3. Click the Add button, then click on the spectrum where the peak centroid should be located. This step can be repeated to insert additional peaks in the ROI.
4. Click Calculate.

To review the change made to the original spectrum, click the Differences button. To save the ROI modification, select OK or Apply.

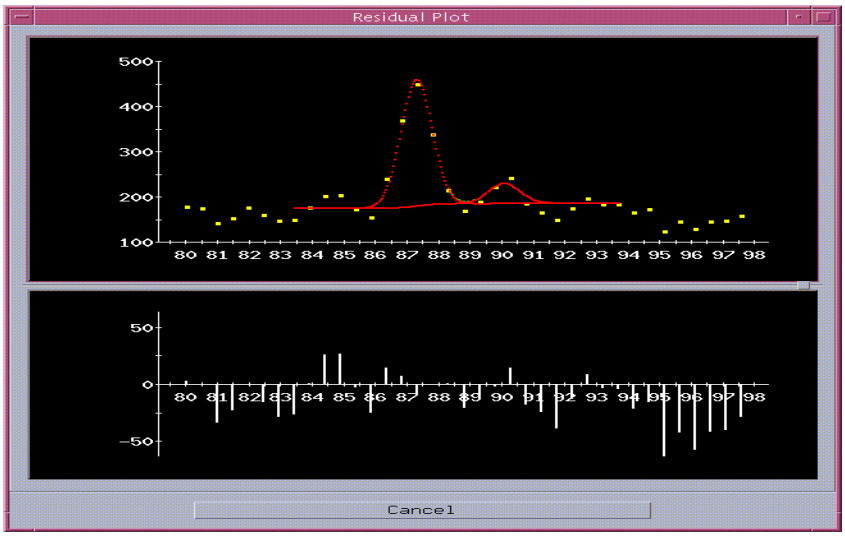


FIGURE 16. RESIDUALS PLOT

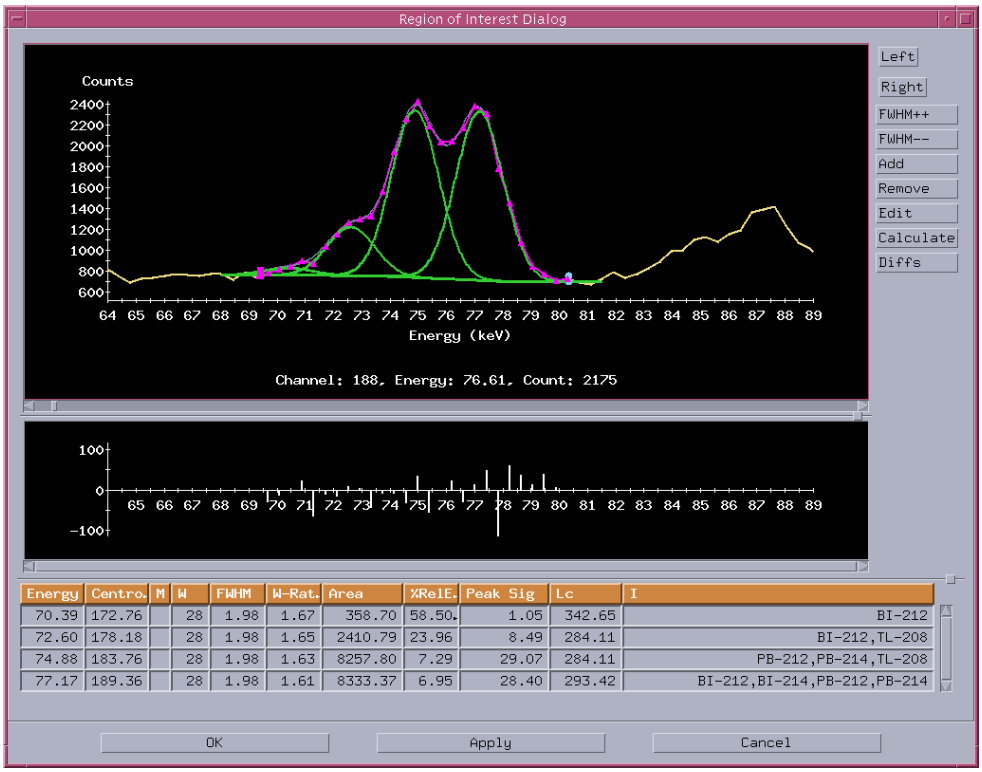


FIGURE 17. REGION OF INTEREST DIALOG

REVIEWING FOR TYPE I AND TYPE II AUTOMATED PEAK SEARCH ERRORS

The next step in the review process is to inspect the automatic analysis peak search results for Type I and Type II errors. A Type I peak search error is a peak found by the automatic search algorithm that is not an actual peak; rather, it is a statistical deviation in the baseline. A Type II peak search error is an actual peak that the automatic search algorithm did not find. The declaration of Type I and II errors rely heavily on the expert judgement of the analysts.

An analyst could spend a considerable amount of time searching the spectrum and correcting all Type I and II peak search errors. To improve the efficiency of the interactive review process, an analyst is usually directed to only look for Type I and II errors for

nuclides that affect the sample characterization. Analysts should concentrate their review to focus on the CTBT relevant radionculides. Unidentified peaks should also be examined to ensure the nuclide identification process is working properly.

In order to help the analyst with determination of Type I errors, the Inspectra Peak Search window shows both the critical level (L_c) and the peak significance (Peak Sig) for each peak. The L_c is the net signal level above which an observed signal may be reliably recognized as detected [Cur68]. L_c is calculated at the default confidence level of 95%. However, the confidence level may be changed by altering the L_c abscissa in the processing template. The peak significance is the calculated peak area divided by L_c.

A special tool has also been implemented in Inspectra to help with the determination of Type I and Type II errors. This tool provides an analyst with the ability to overlay a pseudo L_c peak in any energy region of a given spectrum. To plot the L_c peak, an analyst must click the right mouse button on the baseline where the questional peak structure exists. An example of an L_c peak plot is given in Figure 18.

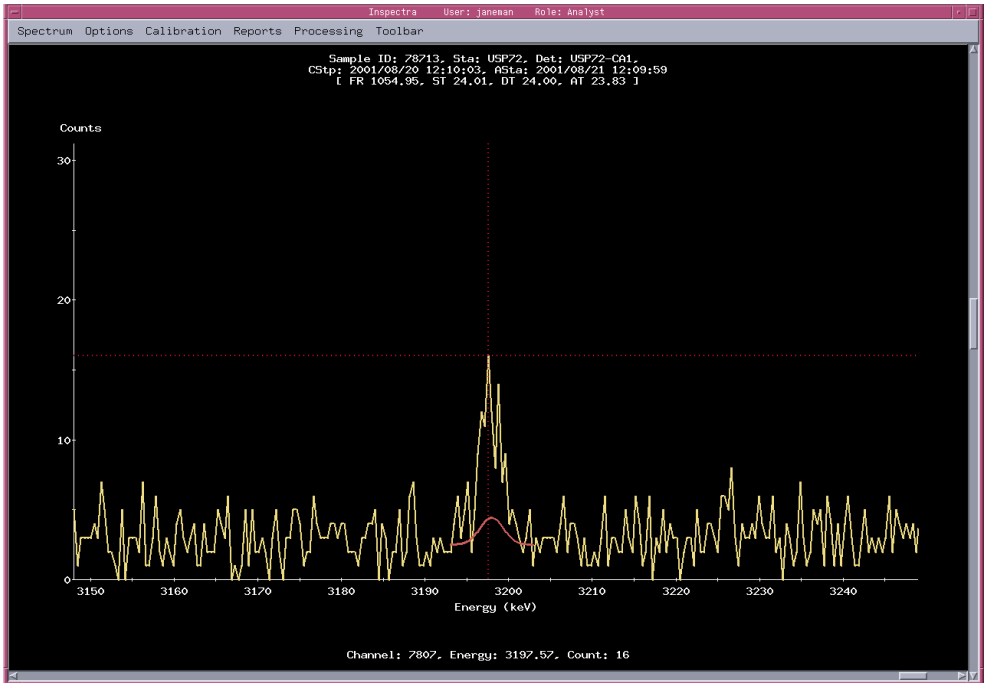


FIGURE 18. L_C PEAK OVERLAY

The analyst begins by reviewing Type I errors using the peak search dialog (Reports>Peak Search). The report may be sorted by nuclide; this will place all unidentified peaks at the top of the report. The Show Graph button can be used to visually examine the unidentified peaks. The analyst should add a comment to each unidentified peak. stating whether the peak is real or not and correctly identifying it. If the peak is real and the analyst is not able to determine the identification, the peak should be labeled "unknown emitter." Many default comments are provided in the Add Comment window.

The width ratio (W-Ratio) in the peak search report is helpful for determining Type I peaks. This is the ratio of the fitted peak FWHM to the FWHM determined by the RER at that energy region of the spectrum. A peak with a FWHM ratio near 1 has a fit commensurate with what is expected. Peak width ratios less than 0.5 are often Type I errors in peak processing. A peak with a width ratio above 1.5 should be examined as a potentially unresolved multiplet.

After all the unidentified peaks are examined, the spectrum should be reviewed for CTBT relevant nuclides. These are the nuclides that affect characterization. Natural peaks of ^{7}Be and ^{212}Pb as well as all anthropogenic peaks identified in the particulate spectra should also be examined. The analyst should make sure that the peaks are real and that the identifications are correct. If the primary lines for ^{7}Be and ^{212}Pb are not present in the particulate spectra, then the analyst should determine the cause. These natural radionuclides should be present in all FULL particulate sample spectra. The analyst should take corrective action if the peaks identified as resulting from CTBT-relevant nuclides are not real, or are incorrectly identified. An analyst may adjust the fit of a peak through the ROI interface (Options>ROI) or remove a nuclide identification with the Remove Nuclide button in the peak search dialog (Reports>Peak Search). An analyst should note all Type I errors in peak processing in their analyst notes.

The search for Type II peak processing errors is facilitated by the nuclide review tool (Options>Nuclide Review). Figure 19 is an example of the nuclide review tool window. This tool displays up to four spectrum regions that correspond to four of the most abundant lines of a chosen nuclide. The menu bar on the right side of the tool contains a list of nuclides. To examine the spectrum for a given nuclide, the analyst clicks the button corresponding to that nuclide. The analyst should examine the channels in the spectrum at the energy location where the peaks are expected to be found. Pseudo peaks are plotted in the nuclide review tool to help the analyst determining if a nuclide is present. Default pseudo peak sizes correlate to the peak area that would result if the nuclide of interest was present at an atmospheric activity level equivalent to 1 MDC. The list of nuclides in the nuclide review tool are user-defined.

If a relevant radionuclide is found by an analyst in the Type II error search, the peak should be inserted with the ROI interface (Options>ROI). All peaks that are inserted or modified should undergo senior-level review.

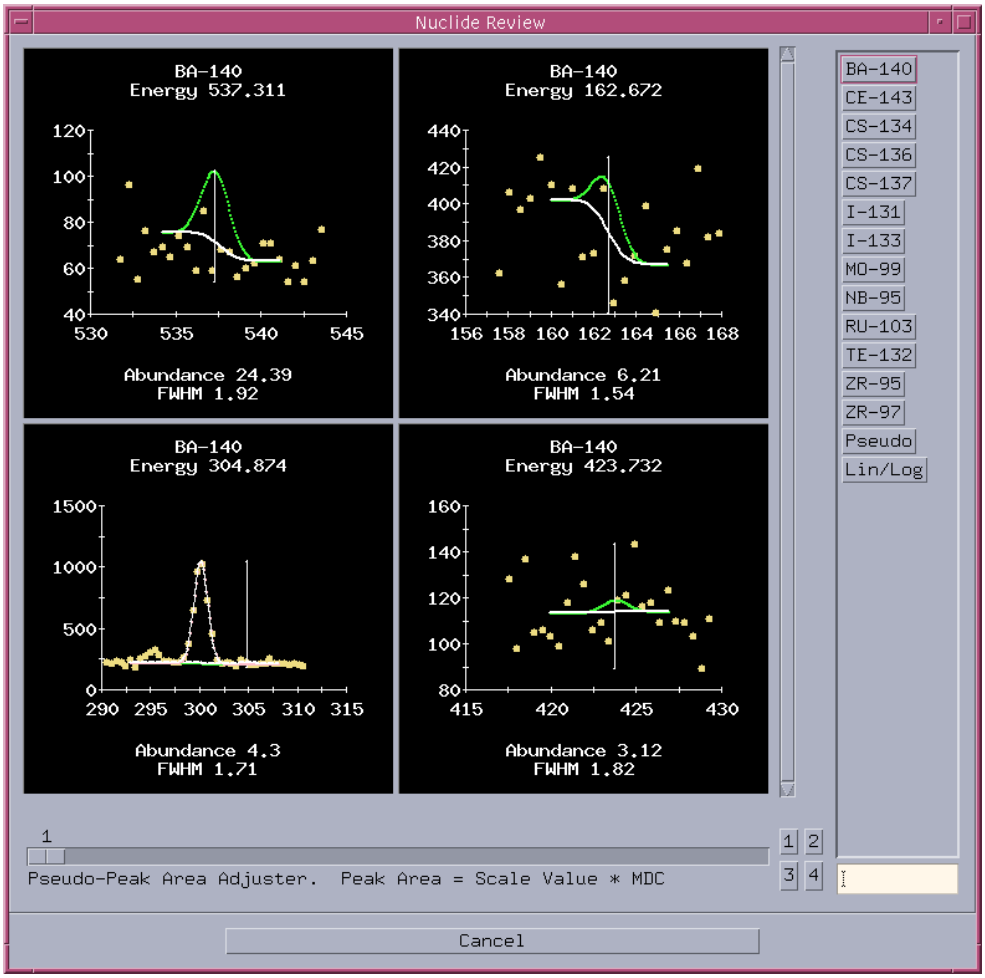


FIGURE 19. NUCLIDE REVIEW TOOL

RELEASING SPECTRA

Upon completion of review, the analyst opens the release window (Processing> Release Sample). From the Sample Release window (Figure 20), the analyst reviews the prioritization of the radionuclides and all comments made about the sample. The analyst has the

option to release the sample, release the sample without categorization, mark other (V - viewed, T - bad calibration, or H - hold for review), pass to another role, or cancel the release.

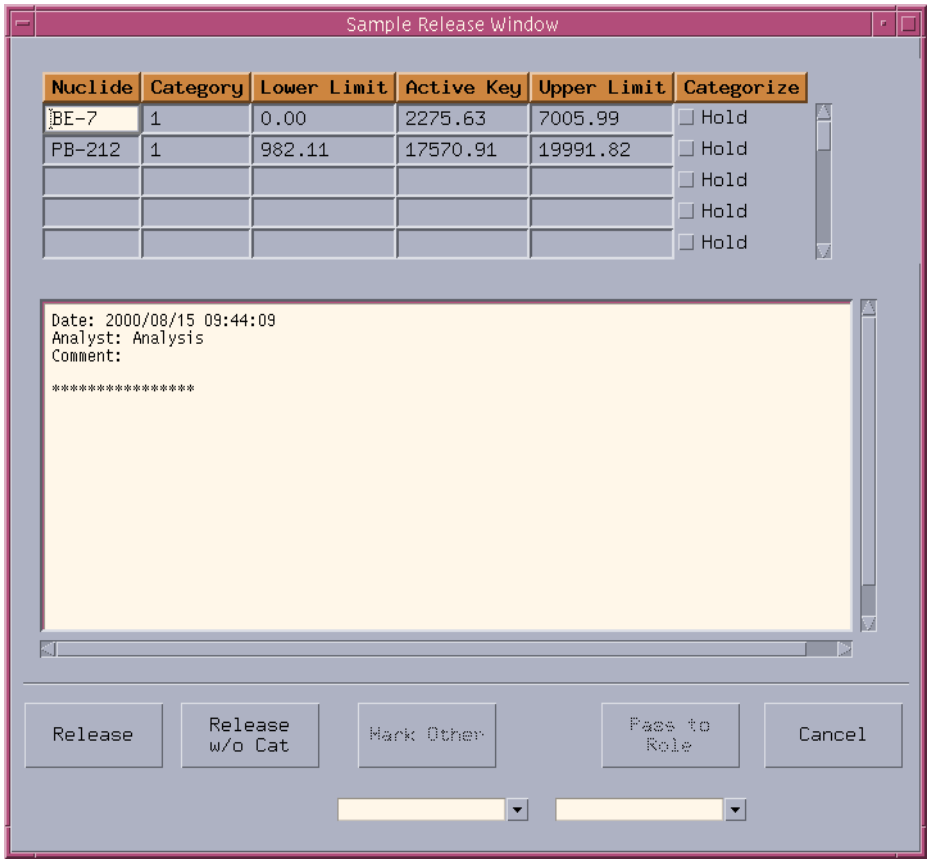


FIGURE 20. SAMPLE RELEASE WINDOW

The Pass to Role feature is utilized for the small percentage of samples that require additional review by IDC staff. This review is performed on radionuclide sample spectra that have had peak modifications, peak additions, or judged by the radionuclide analyst to be problematic or abnormal. The MAR Tool is set up to facilitate multiple levels of review. From the release window, analysts can automatically forward a spectrum for review to

the roles of lead analyst, processing engineer, scientist, and director of operations. Because several persons may share such roles, and the active review of samples can adversely affect Inspectra, it is highly recommended that the persons sharing the role to communicate to one another for the purpose of deciding who should perform the high-level review before opening the sample in question.

As described above, a radionuclide analyst may use the ROI interface to add or modify peaks. This alteration may affect the characterization level of a sample. Such peak modifications and additions usually require the review of additional IDC staff. This additional review will ensure that the correction was necessary and performed correctly.

Problematic spectra fall into two categories: 1) low quality spectra (for example, detector resolution is very bad or the system had a notable gain shift during collection), or 2) spectra that had difficulty with the automatic analysis. For low quality spectra, the senior-level reviewers usually diagnose the problem and notify the IMS. For spectra that encountered difficulties with the automatic analysis, the senior-level reviewer will determine the source of the automatic processing difficulty and institute corrections. Many times, spectra that are of low quality are just marked “Viewed” and are not “Released.” This prevents the propagation of bad data.

Abnormal spectra usually require senior-level review. Abnormal spectra are those that contain radionuclides not normally observed at a given station or spectra that contain normally seen radionuclides at abnormal levels. Currently, senior-level review should focus mainly on abnormalities in radionuclide concentrations in CTBT relevant radionuclides. However, spectra that contain grossly abnormal concentrations of any radionuclide should be referred by the radionuclide analyst for additional review. The senior-level reviewer can verify the presence of the abnormal radionuclide, ensure that its concentration was calculated correctly, and initiate further action that may be required if the spectrum is characterized as a level 4 or 5. The senior-level review process also works to ensure that the statistical prioritization of normally observed radionuclides is functioning properly. If the prioritization process is producing too many (or too few) abnormal instances, then the parameters of the statistical filter should be examined and perhaps changed. After senior-level review of an abnormal spectra, the sample is usually marked “Released,” unless a problem was noted.

After senior-level review, it may be necessary to request a new detector background spectrum be acquired at the station. Having an updated DETBKPHD can clear up any detector contamination cases. A few detector contamination cases should be expected each year.

SUMMARY

The radionuclide review process is performed on every FULL SAMPLEPHD spectral file received from the IMS. The purpose of this review process is to monitor the station SOH, verify the automatic analysis results, and to correct any problems that significantly affect the sample characterization. This review process should take around 15 minutes for an experienced analyst. While the majority of sample spectra are reviewed and released by the analyst, some spectra require senior-level review. Further review at a senior level should provide additional insight into problematic and abnormal spectra. The result of this team effort is a high quality data output by the IDC.

Chapter 2: Interactive Review of 3-D Beta-gamma Coincidence Data

This chapter is a guide for analysts reviewing 3-D beta-gamma coincidence data from IMS noble gas stations and includes the following sections:

Chapter 2: Spectral Review of 3-D Beta-Gamma Coincidence Data

INTRODUCTION

The review process for 3-D beta-gamma coincidence data is similar to that used for high resolution gamma-spectroscopy (see Figure 21). There are differences in the details, however, because of the different nature of the data and the distinct capabilities of the Coincident Radiation Interactive Analysis Tool (CORIANT).

Interactive review of automated results occurs for every FULL SAMPLEPHD received at the IDC. The purpose of this review process is to monitor station SOH and to verify or correct the automatic analysis results. The interactive review process for samples from β-γ coincidence systems should take less time than those from high-resolution gamma spectroscopy systems because the number of possible nuclide signatures is significantly reduced. Only four radioxenon isotopes (^{131m}Xe, ^{133}Xe, ^{133m}Xe, ^{135}Xe) and possibly radon daughters (mainly ^{214}Pb) are detected by such systems.

While most samples are reviewed and released by the analyst, some samples require senior-level review. Senior-level review provides for additional expertise and more insight into problematic or abnormal samples. With the analyst review, the goal of this team effort is an accurate and unbiased analysis of the sample data.

SAMPLE PRIORITIZATION

During automatic analysis, each sample is assigned a priority number. The logic of the prioritization is similar to that for particulate samples. (See Figure 3 on page 18.) The only difference is that there is no Level 2 priority. This is because the noble gas units are designed to remove particulates and non-xenon noble gases from the sample, including those that occur naturally. It is possible to observe β-γ coincidence signatures from the daughter products of radon when the noble gas units are not working optimally or when

the units are placed in areas with high radon concentrations. Although this may be the case, it is still impossible to utilize the β-γ coincidence data to quantify the actual air concentration of radon because the separation efficiency of this nuclide is not reported. Without the ability to quantify the air radon concentration, it is impossible to assign a priority level of 2 to noble gas samples.

All four possible radioxenons (^{131m}Xe, ^{133}Xe, ^{133m}Xe, and ^{135}Xe) are CTBT-relevant anthropogenic radionuclides. Their presence can trigger a level 3, 4, or 5 depending on the quantity and number present in the sample. A summary of the nuclides identified and quantified can be found by clicking the Report pull-down menu and selecting the Release window (Report>Release) in CORIANT. Nuclides with net counts above the L_C are identified.

Even though new, more time independent categorization filters have been included in this version of the software, and it is recommended that analysts review samples in chronological order on a detector basis. This ensures that the prioritization/characterization statistical limit values are properly maintained and that an analyst who is familiar with a station's particular characteristics is reviewing the data. It is also advantageous to first review samples from stations that have a Level 4 or 5 sample. This guarantees that high-priority samples are given proper attention.

Noble gas samples acquired via β-γ coincidence detection are automatically assigned to each analyst by the MAR Tool (which is configured according to the design from the head of Radionuclide Operations). By selecting Spectrum>Assignment in CORIANT, an analyst can access a list of noble gas samples acquired via β-γ coincidence detection that are assigned to him/her. Samples can be opened from the Assignment window. See the chapter on CORIANT in [IDC6.5.10Rev2] for more information on the use of this review tool.

VERIFICATION OF SAMPLING METRICS

Once a sample is opened and the analyst is familiar with the nuclides that have been identified and quantified, it is useful to check the sampling metrics for any irregularities. In many cases, station operators report the occurrence of such irregularities in the

`#Comment` block of the SAMPLEPHD. This text can be viewed by selecting Report>Station Comments in CORIANT. Comments made by IDC staff about the sample can be found in Report>Comments.

Sampling metrics that are useful to review include sampling time (hrs), decay time (hrs), acquisition time (hrs), and volume of stable xenon (cm^3). All of these parameters are located in the Histogram tab of CORIANT on the lower left corner as illustrated in Figure 21. For analysts not yet familiar with the operations of a particular monitoring unit, the database can be directly queried for average values of station-specific sampling metrics using SQL. These should be checked against applicable IMS Operating Requirements.

Because of the direct effect of the sampling metrics on the ability of a station to monitor CTBT compliance, any abnormalities in these parameters should be investigated. Dialog with station operators through the appropriate channels may provide additional information about the sample in question. Notifying the IMS of the abnormality may also be required. Please refer to the appropriate IDC operations procedures for information on handling such cases.

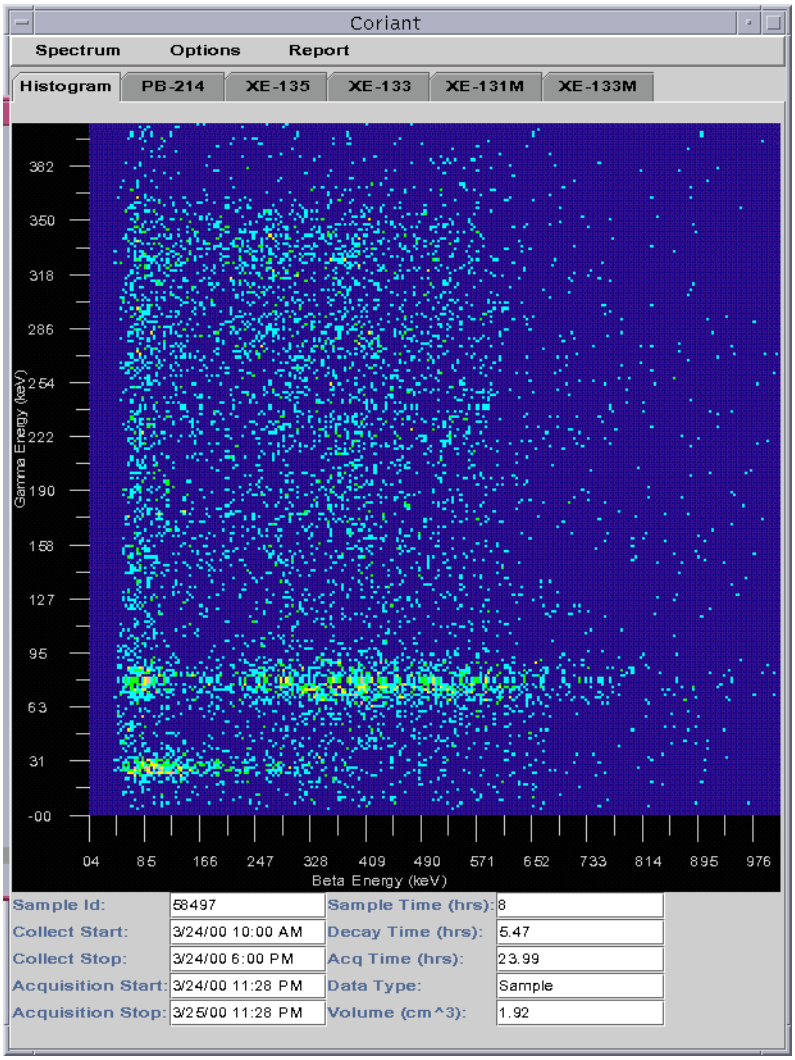


FIGURE 21. HISTOGRAM TAB IN CORIANT

VERIFICATION OF CALIBRATION

Regardless of sample type or detector type, calibration data for the following three parameters are reported in all SAMPLEPHD: energy, resolution, and efficiency. Each will be discussed in turn with respect to the interactive review of β-γ coincidence data from noble gas stations.

Energy Calibration

In a β-γ coincidence detection system, there are two detectors that must be calibrated for energy: the beta detector and the gamma detector. Energy pairs for each detector are reported in the `#b_Energy` blocks and `#g_Energy`, respectively, in the SAMPLEPHD. These energy pairs are used to devise ECR equations to convert channel units to keV as described in "Analysis of Beta-Gamma Coincidence Data" in Chapter 2 of [IDC5.2.2Rev2]. The ECR equations for the beta and gamma axes can be viewed by selecting Report>ECR in CORIANT.

To determine whether these equations are appropriate for the sample, display the ROI boxes in the Histogram window of CORIANT. To do this, select Report>Roi and click on all the boxes at the bottom of the window: Pb-214, Xe-131m, Xe-133, Xe-133m, and Xe-135. If the ROI boxes do not directly overlay the signatures of identified radionuclides, then there is a problem with the energy calibration. If the boxes are higher or lower than the radionuclide signatures, then the energy calibration of the gamma detector is off. It is harder to determine the goodness of the beta detector energy calibration. The best way to do this is to scrutinize the Xe-131m and Xe-133m ROIs when either of these metastable radioxenons are present in a sample. Depending on the station location, the presence of these metastable radioxenons can be very infrequent to always absent. Because of this problem, it is important that the detector be calibrated on a regular and frequent schedule. If there appears to be a problem with the energy calibration, the sample can be reanalyzed with a different ECR. See Chapter 4 of **IDC6.5.10rev2.**

If it is difficult to distinguish the radionuclide signatures in the histogram plot, the Gamma Graph and Beta Graph options from the Report menu in CORIANT may be useful. These are plots of the beta-gated gamma spectrum and gamma-gated beta spectrum, respectively. They are plotted by adding the counts in each row or column of the histo-

gram for each respective plot. It is easy to see peaks in these graphs. Also helpful are the Beta-Gated Gamma Graph and Gamma-Gated Beta Graphs in each nuclide tab window. These are the beta-gated gamma spectrum and gamma-gated beta spectrum valid within that specific ROI. These graphs are even more helpful than the Gamma Graph and Beta graph since the energy spans of the spectra are those defined by the ROI limits.

Resolution Calibration

Resolution pairs for each detector (gamma and beta) are reported in the `#g_Resolution` and `#b_Resolution` blocks, respectively, in the SAMPLEPHD. This information is not currently used in the data analysis. The ROI bounds are dependent on the resolution values, but are reported directly from the station and help define the β-γ coincidence efficiency.

Efficiency Calibration

Three types of efficiency may be reported to the IDC for β-γ coincidence detection systems: gamma efficiency, β-γ coincidence efficiency, and total gamma efficiency. Gamma efficiency pairs are reported in the `#g_Efficiency` block of a SAMPLEPHD. This efficiency type is not currently used for analysis. Beta-gamma efficiency is reported in the `#b-gEfficiency` block of a SAMPLEPHD and is used for converting net counts in a ROI to activity. This type of efficiency is directly dependent on the ROI bounds specified in the `#ROI_Limits` block. Because of this, analysts cannot change the ROI bounds to better fit the radionuclide signatures, although the ECR can be adjusted (see chapter 4 of **IDC6.5.10rev2)**. Sometimes ROI bounds purposefully do not contain an entire radionuclide signature of interest because interference may be likely, for example, in the high beta energy region. Also dependent upon the ROI limits are the count ratios reported in the `#Ratios` block. The β-γ coincidence efficiencies may be viewed in bar-graph form by selecting Report>EER Graph in CORIANT. It is not possible to derive a meaningful regression equation for the beta-gamma coincidence efficiency because it is dependent upon the beta or conversion electron energy, the gamma or X-ray energy, and the bounds of the ROI. The last efficiency type, the total gamma efficiency pairs, is

optional and reported in the `#TotalEff` block of a SAMPLEPHD. Like the gamma efficiency, this efficiency type is not currently used for beta-gamma coincidence data analysis.

Although the only monitorable efficiency type is the β-γ coincidence efficiency, there is no easy way to determine if the values are reasonable for that sample. Again, the performance of regular detector calibrations at the station is important for verifying that the values are up-to-date and valid.

Calibration Sources

Beta-gamma coincidence counting systems designed for CTBT verification purposes are new. Several different calibration sources have been used by different design and development teams. The table below lists some of the radionuclides that have been used to calibrate such systems.

TABLE 3: RADIONUCLIDES USED TO CALIBRATE BETA-GAMMA COINCIDENCE SYSTEMS

Nuclide	Half-life
^{109}Cd	1.27 years
^{135}Xe	9.09 hours
^{137}Cs	30.0 years
^{152}Eu	13.48 years
^{154}Eu	8.60 years
^{207}Bi	38.0 years
^{232}Np	14.7 months
^{235}U	7.04×10^8 years
^{252}Cf	2.65 years

NUCLIDE REVIEW

After verifying that the sampling and calibration metrics are in order, the analyst should scrutinize the nuclide identification and quantification results. The sample prioritization level, categorization level (if one has been assigned), radioxenon activity concentrations with upper and lower statistical limits, and nuclide category numbers are summarized in the Release window of CORIANT. Nuclides with net counts above L_c are identified. A comparison between the net counts and the critical limit for each nuclide is displayed in bar-graph form in the Count Compare window (Report>Count Compare). A break-down of the gross counts in each ROI is illustrated in the Count Summary window (Report>Count Summary). The percentage distribution between interference counts, memory effect counts, Compton continuum counts, background counts, and net counts is displayed in pie-chart form. See "Analysis of Beta-Gamma Coincidence Data" in Chapter 2 of [IDC5.2.2Rev2] for an explanation on how each of these contributions to the gross counts is determined by *rms_xanalyze*. Identical pie charts are located in each nuclide tab window.

To compare the current sample's radioxenon activities to the previous month's at that station, select Report>Roi and right-click on the radioxenon of interest. This brings up another pull-down menu from which the Concentration window may be chosen. From the same pull-down menu, a plot of the MDCs for that nuclide for the past 30 days at that station can be opened. This plot can be reviewed to verify that the MDCs are at acceptable levels. The MDC values are dependent upon the amount of interference counts, memory effect counts, Compton continuum counts, and background counts. If a large percentage of the gross counts result from these sources, the MDC will be correspondingly high. An in-depth discussion of determining MDCs for β-γ coincidence detection systems can be found in [Bie01b].

To verify the presence of the memory effect in a sample, the GASBKPHD associated with the sample can be viewed with CORIANT. Open the most recent GASBKPHD from the same detector. The nuclides identified in the GASBKPHD will have memory effect counts in the following sample. It is possible to reanalyze a sample without using the GASBKPHD. See chapter 4 of [IDC6.5.10Rev2].

The presence of background radiation, as measured in a DETBKPHD, will appear as background counts in a ROI. The most recent DETBKPHD may be opened for viewing using CORIANT to verify the presence of background radiation. It is important that such counts be performed regularly at a station so that the information maintains its relevancy. It is possible to reanalyze a sample without using the DETBKPHD. See chapter 4 of **IDC6.5.10rev2**.

TYPE I AND TYPE II ERRORS

Currently it is not possible to add or remove nuclides with CORIANT. If an analyst believes they have found a type I or II error, he/she can add a comment to the sample by selecting Report>Roi. The nuclide of interest is right-clicked and a comment may be added to the sample. General sample comments can be added in the same manner.

The inability to add or remove nuclides using CORIANT also implies that the priority or categorization level of a sample cannot be changed during interactive review. Therefore, the analyst may do two things in this situation:

1. add comments to a sample to identify an incorrect priority/categorization level, and
2. mark the sample as Viewed or Release without Categorization (instead of Released).

Upon verification of a sample's priority, sampling metrics, detector calibration, nuclide identification results, and nuclide quantification, the analyst may release a sample if it does not require senior-level review. This is performed through the Release window from the Report pull-down menu. An analyst may also mark the sample as Viewed, Release without categorization, or pass the sample on for senior-level review using the same window.

SENIOR LEVEL REVIEW

Samples that require secondary review may be passed onto a lead analyst or the head of Radionuclide Operations. This is usually done when there is a problem with the automatic analysis results, the sample is abnormal, or to confirm a high priority level (level 4

or 5). Additional comments may be added to the sample by selecting Report>Roi, as described in "Type I and Type II Errors" above. At this time, it is not possible to change the categorization level of a sample via CORIANT. Therefore, comments may be added to a sample to identify an incorrect priority/categorization level and the sample may be marked as Viewed (vs. Released).

Actions to take for abnormal or problematic samples are the same as those listed in "Senior Level Review" in "Interactive Review Procedures for Gamma-ray Spectra" on page 12. Please refer to this section for additional guidance if necessary.

References

[Bie01b] Biegalski, K., and Biegalski, S., "Determining Detection Limits and Minimum Detectable Concentrations for Noble Gas Detectors Utilizing Beta-Gamma Coincidence Systems," *Journal of Radioanalytical and Nuclear Chemistry,* 2001.

[CTB99a] "Certification of IMS Radionuclide Laboratories," CTBT/PTS/ING.96, 1999.

[CTB99c] "Radioxenon Data Processing and Analysis for the CTBT Verification," CTBT/WGB-9/US/1, 1999.

[CTB00b] "Recommended Standard List of Relevant Radionuclides for IDC Event Screening," Report of Informal Workshop, Melbourne, WGB/TL-2/40, 2000.

[Cur68] Currie, L., *Limits for Quantitative Detection and Quantitative Determination*, Analytical Chemistry, 40, 3, 1968.

[Pop01] Popov, Vladimir. *Analysis of ARIX Data using IDC R3 Software and ARIX Polyformat Software*. 2001.

[IDC3.4.1Rev3] Science Applications International Corporation, Veridian, *Formats and Protocols for Messages, Revision 3,* SAIC-00/3005, Veridian-TN2829, 2001.

[IDC5.2.2Rev2] Veridian, *IDC Processing of Radionuclide Data, Revision 2,* TN2872, 2001.

[IDC6.5.10Rev2] Veridian, *Radionuclide Software User Manual, Revision 2,* TN2874, 2001.

[IDC7.1.10Rev2] Veridian, *Radionuclide Software Design, Revision 2*, TN2875, 2001.

.

Glossary

Symbols

2-D

Two-dimensional.

3-D

Three-dimensional.

β

Beta, as in beta particle.

γ

Gamma, as in gamma-ray.

A

acquisition live time

Time multichannel analyzer (MCA) electronics is available for processing pulse amplitude signals; equivalent to acquisition real-time less detector dead-time, reported in seconds.

acquisition start

When the detection system at a station commences sample acquisition.

activity

Decay rate of a radionuclide; this quantity is usually expressed in Becquerels (disintegrations per second), Bq.

anthropogenic

Man-made, not of natural origin.

ARR

Automatic Radionuclide Report. This report is a product of the automatic data processing and includes sections describing the sample information, prioritization results (noble gas only), sample activity, MDCs for key nuclides, peak search results and notes, processing parameters, update parameters, data quality flags, event screening flags, calibration equations, and field of regard.

ASCII

American Standard Code for Information Interchange. Standard, unformatted 256-character set of letters and numbers.

B

background

Contribution to a spectrum from naturally occurring radionuclides as well as interactions between radiation and materials in the vicinity of the detector.

Becquerel

Unit of activity equal to one disintegration per second; denoted by Bq.

beta-gamma coincidence efficiency

Ratio of counts detected in a 2-D ROI to the actual amount of photons emitted by a sample in coincidence with an electron; depends on detector configuration, geometry, and ROI boundary limits.

beta-gamma coincidence event

Nuclear decay that produces both a gamma ray and a beta particle within a very short time scale. May also refer to other photon-electron coincidence events such as an X-ray with a conversion electron.

beta-gated gamma spectrum

Gamma spectrum in which all photons counted were detected in coincidence with an electron.

beta particle

Electron that is produced from a nuclear decay. May also refer to other electron radiations, for example, a conversion electron.

BLANKPHD

Blank Pulse Height Data; ASCII data message containing the pulse height data of an unexposed air filter, as well as other information, in an IDC-approved format.

Bq

Becquerel.

C

CALIBPHD

Calibration Pulse Height Data; ASCII data message containing the pulse height data of a certified standard source, as well as other information, in an IDC-approved format. The data in a CALIBPHD are used to determine the ECR, EER, and RER.

calibration

Process of determining the response function and sensitivity of an instrument or its derived channel.

calibration coefficients

Numbers that define the energy, resolution, and efficiency equations.

calibration energy

Part of the energy/channel pairs that make up a detector's energy calibration data.

category

Number from 1 to 5 assigned to a radionuclide sample during interactive analysis indicating the presence of certain types of nuclides. Category 1 indicates a spectrum with normal natural nuclides while 5 indicates spectra with multiple man-made nuclides.

centroid

Energy (in keV) or channel number at the center of a fitted peak.

certified laboratory

Radionuclide laboratories listed in Annex 1 of the CTBT and including any laboratories that are certified by the IMS/IDC in the future.

channel

An energy window (in keV) representing a differential increment of pulse height.

click

Select an element on the screen by positioning the pointer over the element, then pressing and immediately releasing the mouse button.

cm

Centimeter.

CMR

Center for Monitoring Research.

collection start time

Time at which the collection equipment at a station commences sample collection.

comments

Free text field containing comments made by a station operator or IDC analyst.

concentration

Activity per unit volume of air.

CORIANT

Coincident Radiation Interactive Analysis Tool.

counts

Number of pulses observed within a spectrum channel.

critical level

Minimum net counts that must be contained in an ROI for reliable nuclide detection (L_c).

CTBT

Comprehensive Nuclear Test-Ban Treaty.

D

d

Day(s).

data type

Kind of data in a data message. R: Radionuclide data types include: ALERT_FLOW, ALERT_SYS, ALERT_TEMP, ALERT_UPS, ARR, BLANKPHD, CALIBPHD, DETBKPHD, GASBKPHD, MET, QCPHD, RLR, RMSSOH, RNPS, RRR, SPHDF, SPHDP, and SSREB.

decay time

Duration of time an exposed filter is allowed to decay before data acquisition begins.

DETBKPHD

Detector Background Pulse Height Data; ASCII data message containing the pulse height data from a background count, as well as other information, in an IDC-approved format.

detector type

Data field describing the type of radiation detector used in the data acquisition process.

dialog box

Box that appears on the screen after you issue a command and requests information or a decision.

E

ECR

Energy versus Channel Regression; an equation providing the initial detector-specific relationship between channel number and energy.

EER

Efficiency versus Energy Regression; an equation providing the detector-specific relationship between efficiency and energy.

efficiency

Ratio of counts detected under a photopeak to the amount of radiation quanta emitted by a sample; depends on detector configuration and geometry.

efficiency energy

Component of the energy/channel pairs composing a detector's energy calibration data; energy at which a certain efficiency value is valid. Reported in keV.

energy

Usually refers to the measured kinetic energy of radiation quanta deposited in a detector. The unit most appropriate for such measurements is keV.

energy span

Energy interval in which a multi-channel analyzer counts radiation quanta. Usually equivalent to the highest energy on the gamma or beta axis, rounded to the nearest 100 keV.

event

Occurrence that displays characteristics indicative of a possible nuclear weapons test.

F

flow rate

Air volume passing through an air filter per unit time; reported in scm (m^3)/hr.

FULL

Full; spectral identifier indicating that the sample has been counted for the total acquisition duration.

FWHM

Full Width at Half-Maximum; metric of detector resolution and equivalent to the width of a photopeak (in keV) taken at the peak height equal to half the maximum peak counts.

G

gain

Amplification of the measured energy deposition in a radiation detector. This is achieved through the use of electronic amplifiers.

gamma

Gamma-ray.

gamma-gated beta spectrum

Beta spectrum in which all electrons counted are detected in coincidence with an electron.

gamma-ray

Photon that is produced from a nuclear transition; may also imply other photon radiations, for example, an X-ray.

GARDS

Global Atmospheric Radionuclide Detection System; the network of radionuclide monitoring stations that meet CTBT requirements and transmit radionuclide data to the IDC with coordination by the IDC.

GASBKPHD

Gas Background Pulse Height Data. Data type sent by noble gas monitoring systems that observe a memory effect during sample acquisition due to atoms from the previous sample adsorbed onto the walls of the gas cell. The counts from the memory effect must be subtracted from the sample counts for accurate activity quantification.

GUI

Graphical User Interface.

H

h

Hour(s).

half-life

Time required for a radionuclide to decay to half its initial activity.

histogram

Two-dimensional array containing beta-gamma coincidence counts. One axis represents gamma channels (or energy) while another represents beta channels (or energy). The data in a histogram may be plotted in 3-D or as a 2-D contour plot.

hr

Hour(s).

I

ID

Identification; identifier.

IDC

International Data Centre.

IMS

International Monitoring System.

Inspectra

GUI-based tool that facilitates interactive review and analysis of the automated spectral data processing results.

K

keV

Kiloelectron Volts; a metric of kinetic energy.

L

L_c

Critical Level.

M

m

(1) Meter(s). (2) Megabyte(s); 1,024 kilobytes. (3) Month(s). (4) Minute(s).

MAR Tool

Multiple Analyst Review Tool.

MDC

Minimum Detectable Concentration.

minimum detectable concentration

Activity concentration of a given radionuclide that is indistinguishable from the measurement process noise level.

MRP

Most Recent Prior; the sample counted most recently on the same detector and originating from the same station as the sample presently being analyzed.

multiplet

Spectrum region of interest composed of more than one photopeak.

N

natural radioactivity

Radioactivity from cosmogenic and primordial nuclides that is always present on earth.

NID

Nuclide Identification.

noble gas

Noble element of the periodic table: He, Ne, Ar, Kr, Xe, and Rn.

nuclide

One of many combinations of nucleons that may comprise an atomic nucleus. Because all nuclides of interest with respect to CTBT compliance verification are radioactive, this term is often used to refer specifically to radionuclides.

O

ORACLE

Vendor of PIDC and IDC database management system.

P

peak

Statistically significant increase in counts above a spectrum baseline at an energy associated with a gamma line of a particular radionuclide or other phenomenon.

PHD

Pulse Height Data; a format for spectral data messages. Possible PHD data message types include SAMPLEPHD, BLANKPHD, DETBKPHD, CALIBPHD, GASBKPHD, and QCPHD.

PIDC

Prototype International Data Centre.

PL/SQL

Procedural Language for SQL.

pop-up

Small window that contains selectable objects such as filter settings.

PREL

Preliminary; usually referring to a SAMPLEPHD with an acquisition time less than that of the full acquisition duration.

priority

(1) Number from 1 to 4 assigned to an identified nuclide indicating whether or not the nuclide is natural or anthropogenic and if the nuclide is above or below normal observation levels.
(2) Number from 1 to 5 assigned to a radionuclide sample during automatic analysis indicating the presence of certain types of nuclides. Category 1 indicates a spectrum with normal natural nuclides while 5 indicates spectra with multiple man made nuclides.

pull-down

Small list of selectable objects, such as menu items, which appears below a menu heading.

Q

QC

Quality Control.

QCPHD

Quality Control Pulse Height Data; ASCII data message containing the pulse height data of a certified source as well as other information. Information in the QCPHD, along with other data, is used to check a detector's state of health.

quantity

Collected air volume in scm; same as sample air volume.

R

radioactivity

See activity.

radionuclide

Nuclide that has an unstable nucleus, that is, a radioactive nuclide.

radionuclide laboratory

Laboratories listed in Annex 1 of the CTBT and include any laboratories that are certified by the IMS/IDC in the future.

region of interest

Region of a radionuclide spectrum or histogram that corresponds to a particular radionuclide.

resolution

Metric of a detector's ability to detect photons at discrete energies and is equivalent to the FWHM.

RMS

Radionuclide Monitoring System; the part of the IMS that monitors the atmosphere for radionuclides.

ROI

Region of Interest.

ROI number

Integer from 1 to 6 assigned to a 2-D ROI for the analysis of 3-D beta-gamma coincidence data.

RRR

Reviewed Radionuclide Report. Electronic file containing the results of the interactive review of the automated radionuclide processing. It contains sections on sample information, measurement categorization, measured radionuclide quantities, MDCs, radionuclide identification, analyst editing, processing parameters, data quality flags, event screening flags, calibration equations, and field of regard.

S

s

Second(s).

sample

The solid or gaseous entity collected by a blower at an RMS station that is analyzed for its radioactive contents.

SAMPLEPHD

Sample Pulse Height Data; ASCII data message containing pulse height data acquired by counting a gas or particulate sample with a detector system.

scm

Standard Cubic Meter(s).

select

To choose an item on the screen by clicking it with the mouse pointer.

SOH

State-of-health; indicator of a system's operability.

spectral qualifier

Code in a SAMPLEPHD that indicates whether the spectrum acquisition time is truncated (PREL) or full (FULL).

spectrum

Plot of the differential number of pulses (in counts) per differential pulse height (in channels or keV).

SPHD

Sample Pulse Height Data; ASCII data message type containing the pulse height data of a sample, as well as other information. The two types of SPHDs are FULL and PREL (preliminary).

SQL

Structured Query Language; a language for manipulating data in a relational database.

SSREB

Standard Screened Radionuclide Event Bulletin; bulletin generated by the IDC when fission or activation products are detected at a radionuclide station above normal limits. A SSREB contains information on the possible event, source location, fission products, activation products detected, any isotopic ratios calculated, and any certified laboratory results. New event information can be added to the SSREB as it arrives, therefore, multiple revisions of an SSREB are possible.

standard cubic meter

Volume occupied by $1m^3$ of gas at 0 C and 1013 hPa.

station

Site where a monitoring instrument is installed.

T

total efficiency

Ratio of gamma rays interacting with the detector crystal to the total number emitted by a sample.

Trendvue

GUI-based tool that facilitates trend analysis of meteorological, station, detector, and radionuclide data.

Type I error

Spectral region of interest falsely identified as a peak by the automated processing.

Type II error

Peak undetected by the automated processing.

U

uncertainty

Estimate of the deviation from the true mean for the parameter or variable of interest.

W

Web

World Wide Web; a graphics-intensive environment running on top of the Internet.

Y

Y

Year(s).

▼ Glossary